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RESEARCH ARTICLE

THE EFFECTS AND INTERACTIONS OF THE MAIN KNITTED FABRICS PARAMETERS

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Abstract

In the work reported here, plain and 1*1 rib flat knitted acrylic fabrics, of three clows were subject to four relaxation treatments, in order to investigate their dimensional stability. The key element studied to understand the dimensional behaviour of knitted fabrics is the geometry of the loop. For the case, we have measured the structural parameters, thickness, weight and course and wale shrinkages.

Introduction:-

The quality of a knitted fabric is undissociated from the dimensional stability concept. It remains both a major and an update problem for the manufacturer, the retailer, the garment maker and the consumer. Several studies have been carried out in this subject. One of the most important results is that of Munden (1959) who reported the independence of loop configuration (or loop shape factor) from the clow of fabric construction and of the physical properties of the yarn. Nevertheless, shrinkage or behaviour of prediction of loops has been difficult to study because of the complexity of knitted structures. Indeed, the shrinkage of a knitted fabric is determined by a number of factors, such as fibre properties, clow, knitting tension and relaxation treatment.

Experimental

In this work, the fabrics were knitted on a flat jacquard electronic knitting machine (Protti PV92SX) with the English gauge E7.The samples have been knitted by changing:

1. The clow value which characterise the tightness of the knit. It reveals to the yarn length absorbed by stitch. This parameter is achieved by regulating the position of the falsest cam (the positions chosen are: 8; 6.5; 5; 3,5).
2. The type of stitch constructions (jersey or rib 1&1).
3. The relaxation treatment (four relaxation treatments).

Detailed information about the yarn used to produce these fabrics samples are presented in *Table 1*.

Table 1:- Details of the yarn used.

Fibre type*	Yarn count (Nm)	Breaking force (N)	Turns/m	Elongation (%)
Fixed acrylic	28/2	3.61	548	6.78

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(*) The use of fixed acrylic materiel rather than High Bulk (HB) acrylic is chosen in order to study the dimensional behaviour of the knitted fabric apart from the dimensional changes that can take place in the fibre structure since it is the case of the 50% HB acrylic fibres under high temperature.

Fabrics were subject to four relaxation treatments:
1. Dry relaxation treatment (T1): Knitted samples were kept without tension on a flat surface under normal conditions. Three pairs of data lines were then marked out in each sample with undelible ink.
2. First wet relaxation treatment (T3): We adopted JJF Knapton’s, FJ Ahrens’s, WW Ingenthorn’s, W Fong’s method (ITF), the same adopted by Jiang TAO, R.C Dhingra, C.K Chan, AND M.S Abbas (1997). Fabric samples were immersed in a water bath containing 0.1% wetting agent maintained at a constant temperature of 40°C, and allowed to statically relax in the bath for 24 hours. The bath temperature used for the 3rd treatment corresponds to the wash temperature of Acrylic.
3. Second wet relaxation treatment (T2): The same as the previous treatment except that the bath temperature was maintained at normal conditions.
4. Third wet relaxation treatment (T4): Relaxlab relaxation: We used the French norm NFG 07-102 test method (AFNOR).

After each wet treatment, samples were then hydro-extracted. Linear shrinkage percentages S_L were calculated for each sample using the formula below:

$$S_L = 100 * \frac{(l_0 - l_1)}{l_0} ; \qquad \text{Equation 1}$$

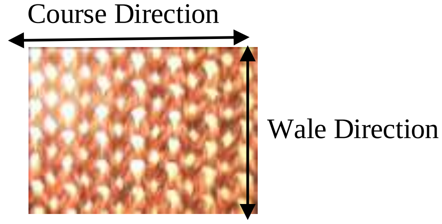
l_0 is the distance between data lines before treatment and l_1 after treatment.
The area shrinkage is as follow:

$$Area\ \ shrinkage\ (\%) = \frac{(15^2 - L * l)}{15^2} * 100\ ; \qquad \text{Equation 2}$$

l [cm] and L [cm] are respectively the wale length and the course length after stabilisation
15 is the wale/course length [cm] before stabilization

Thickness was daily calculated for each sample after each treatment by means of SODEMAT instrument (NFG 07-153).

The second parameter calculated is Fabric loop shape factor S using the relation $S = \frac{c}{w}$.
Where c is the number of courses/cm and w the number of wales/cm.



Results And Discussion:-

Effect of relaxation treatment on dimensional stability

With dry relaxation (*Figure 1*.a), 1&1 rib fabric needs 30 days to be relaxed, which is nearly impossible in industrial application. Dry relaxed samples were faced to progressive shrinkage in both course and wale directions. While with the Relaxlab relaxation (*Figure 1.d*), few days are sufficient to bring fabric to a fully relaxed state. It appears that agitation, added to heated vapour and a wetting agent helps to remove the stress on the loops much more efficiently.

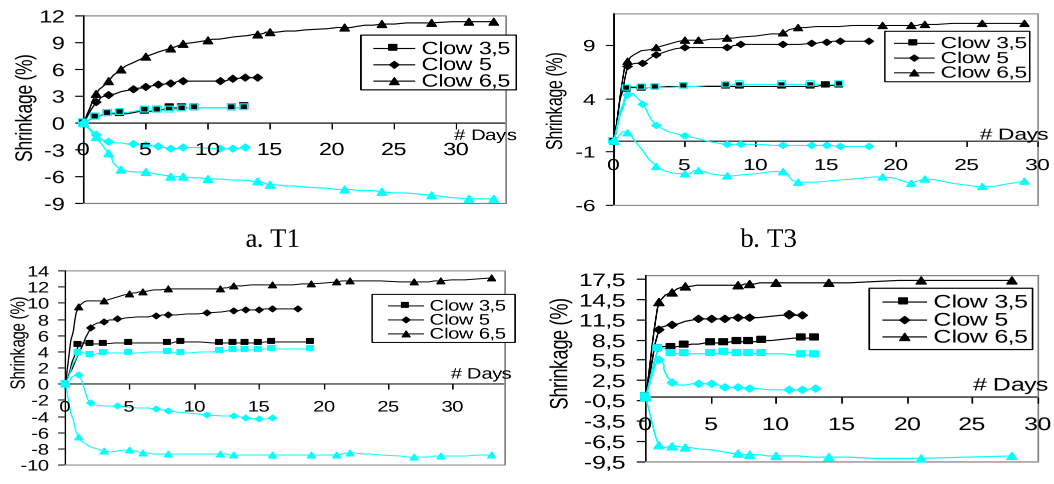


Figure 1:-Wale (—) and course (—) shrinkage of 1*1 Rib Knitted Fabric.

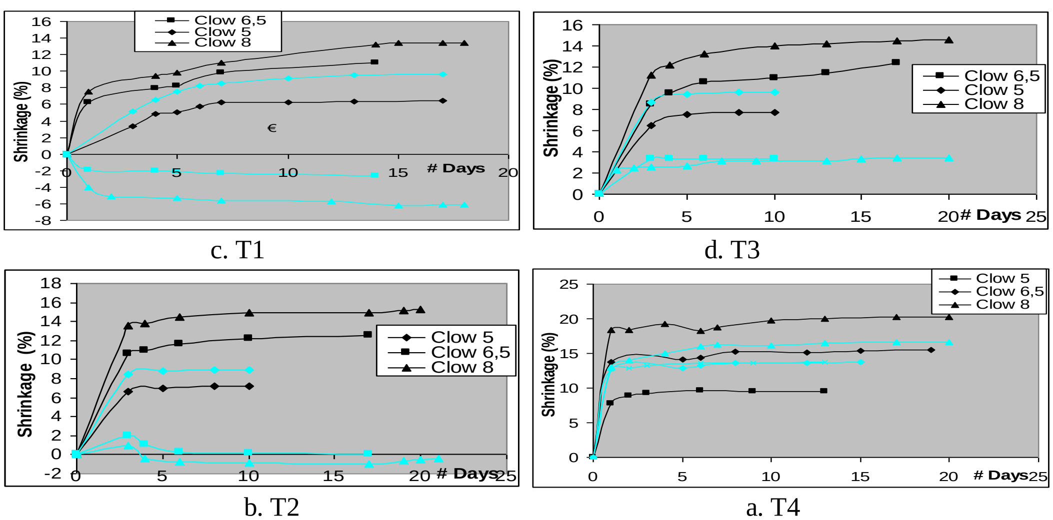
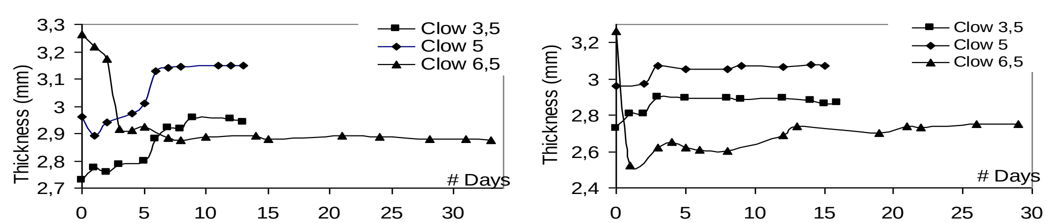


Figure 2:- Wale (—) and course (—) shrinkage of Plain Knit Fabric.

Figures 1 and 2 show that for both knits, wale shrinkage (black curves) is more apparent than course shrinkage (blue curves) for each treatment. The shrinkage behaviour in the wale direction is essentially attributed to the draw down force applied in the wale direction, which makes courses tend to move in the opposite direction after knitting.

Wale shrinkage and course stretching of 1&1 rib knitted samples (*Figure 1*) have lead to a non monotonous thickness variation for most treatments (*Figure 3*). Whereas plain samples have rather shown a thickness increase due the wale and course shrinkages (*Figure 4*).



a. T1 b. T3

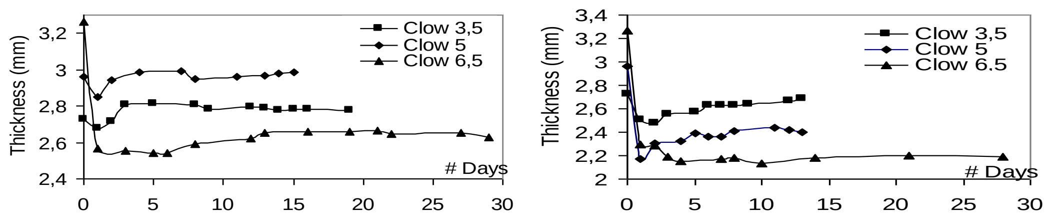


Figure 3:- Variation of thickness with the number of days.1*1Rib knit.

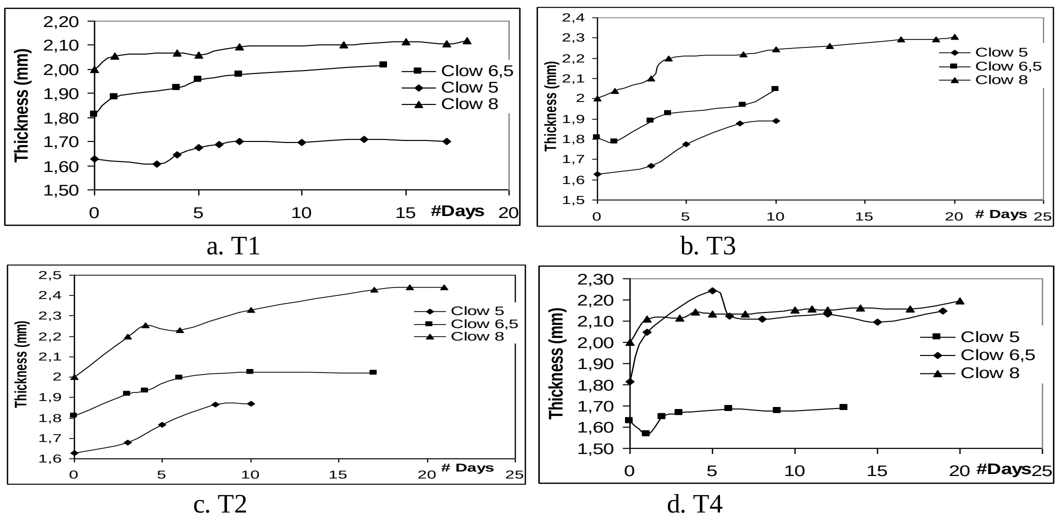


Figure 4:- Variation of thickness with the number of days. Plain Knit.

Effect of fabric clow on dimensional stability

Samples knitted on the same machine gauge with varying clow factor have varied stabilities in length and width directions. For 1&1 rib (*figure 1)*, increase in fabric clow causes a rise in fabric wale shrinkage for each relaxation treatment. In the course direction, we can rather observe a stretching increase of the slackly samples.

For plain structure (*figure 2)*, loosely knitted samples (samples with higher clow value) have higher shrinkage in both directions. This is essentially reported to the plain rolling characteristic.

Thus, for both structures, dimensional changes are greater for slackly acrylic fabrics than for those that are tightly knitted, for both wet and dry relaxations. The shrinkage/stretching increase with clow of both knits is attributed to the ease of yarn when the fabric becomes slacker.

Effect of relaxation treatment on structural parameters

The measured loop shape factor S is summarized before (To) and after the relaxation treatments in *Table 4*. The effect of water, heat and vibration on acrylic 1&1 rib loop shape depends on fabric clow. For 1&1 Rib, it was found that the ratio of courses to wales becomes steadily smaller if clow increases. These observations are in agreement with Postle works (1968, 1969).

The two wet relaxation methods including immersion in water for 24 hours show a comparable loop shape factor for both structures (columns T2 &T3) . Thus, 40° bath temperature hasn't an effect on loop shape factor.

Table 4:- Structural parameters before and after treatment.

			C						W						$S = \frac{c}{w}$			
	Clow	To	T1	T2	T3	T4		To	T1	T2	T3	T4		To	T1	T2	T3	T4

Plain	5	6,98	6,01	6,16	6,24	6,56		4,38	4,64	4,68	4,65	4,99		1,59	1,30	1,31	1,32	1,34
	6.5	3,57	3,25	3,29	3,81	3,3		3	3,68	3,8	3,38	4,38		1,19	0,88	0,75	0,87	1,13
	8	1,91	2,01	2,13	2,16	2,6		2,94	2,21	2,52	2,5	3,9		0,65	0,91	0,67	0,85	0,86
1&1 Rib	3,5	8,33	6,5	7,4	7,34	6,97		4,45	4,74	4,72	4,67	4,71		1,87	1,37	1,56	1,58	1,48
	5	3,87	4,33	4,33	4,35	4,62		3,8	3,7	3,69	3,76	3,6		1,02	1,17	1,18	1,15	1,28
	6,5	2,85	3,18	3,2	3,31	3,4		3,11	2,93	2,86	2,93	3		0,92	1,09	1,16	1,09	1,13

To: before treatment

The evolution of structural parameters with the inverse of loop length (cm) after each relaxation process presents linear variations (Equation 3; Equation 4).

$$c = f(\frac{1}{l}) = a\frac{1}{l} + b \quad \text{Equation 3}$$

$$w = f(\frac{1}{l}) = a'\frac{1}{l} + b' \quad \text{Equation 4}$$

Table 5:- $c = f(\frac{1}{l})$; $w = f(\frac{1}{l})$

		$c = f(\frac{1}{l})$			$w = f(\frac{1}{l})$		
		a	b	R^2	a'	b'	R^2
Plain	Before treatment (To)	2.987	1.058	0.98	11.053	-5.556	0.99
	After dry relaxation (T1)	8.539	-3.597	0.99	4.846	-0.663	0.90
	After second wet treatment (T2)	8.666	-3.622	0.99	4.354	-0.092	0.92
	After first wet treatment (T3)	8.540	-3.507	0.99	4.182	0.024	0.90
	After Relaxlab relaxation (T4)	8.706	-3.344	0.97	2.259	2.477	0.98
1&1 Rib	Before treatment (To)	8.766	-3.953	0.99	1.964	1.777	0.94
	After dry relaxation (T1)	5.094	-0.542	0.99	2.719	1.007	0.97
	After second wet treatment (T2)	6.596	-1.792	0.99	2.795	0.888	0.97
	After first wet treatment (T3)	6.550	-1.680	0.99	2.685	1.048	0.96
	After Relaxlab relaxation (T4)	5.484	-0.615	0.99	2.620	1.088	0.99

R^2 : coefficient of determination

Weight variation

Weight changes after relaxation treatments have also been studied since it is the main point defining knitted fabrics selling. Thus, the hosier could predict the right clow to adopt when knitting for a predetermined relaxed area weight. For this case, we measured weights variation after each treatment and for each clow value (NFG 07-150). Weight per square cm variations is measured using the relation b Equation 5

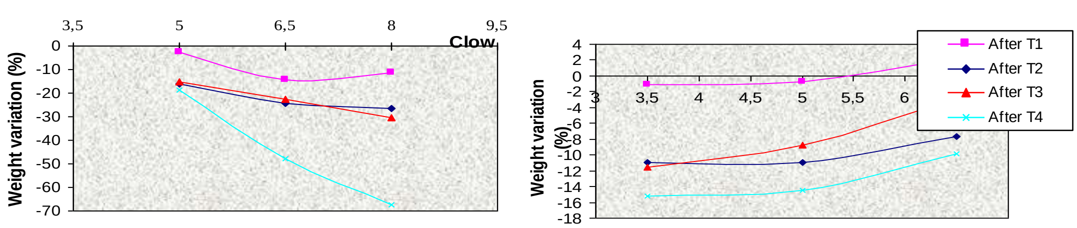


Figure 5:- Weight variation of plain (a) and 1*1 Rib knitted fabrics (b) with clow after relaxation treatments.

By the mean of the first observation, we can conclude that plain samples show advanced weight changes than 1*1 rib ones which is the case of each treatment. The second remarkable thing revealed from *Figure 5* a and b is the evolution of the percentage of weight variation with clow. Thus, 1*1 rib samples weight decreases, whereas plain knitted ones have their weight increasing when increasing clow value. These remarkable differences for the two structures are resulted from the plain shrinkage occurring in both directions.

Treatment effect on recovery percentage

The knitted fabric state was studied through measuring the recovery percentage defined as of the load under a tensile test (NFG 07-140) (*Figure 6*).

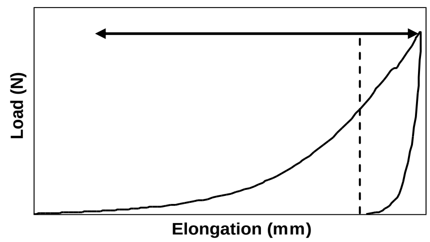


Figure 6:-Load-Elongation curve.

Each treated sample was submitted to an increasing load until reaching 78% of the maximum tensile load of the correspondent treatment in both directions as shown in *Table 5*.

Table 5:- 78% of the maximum tensile load of plain and 1*1 Rib knits.

	Wale Direction	Course Direction
1&1 Rib	450 N	95.77 N
Plain	265 N	165 N

Submitted to a load then to an unload, each knitted fabric type shows a wales recovery higher than that of course direction (*Figure 7*) for each treatment. This is reported to the draw down load exerted when knitting in the course direction to maintain the knit in the needles.

Each treated sample has reached the dimensional stability, but no single sample resumed its initial state.

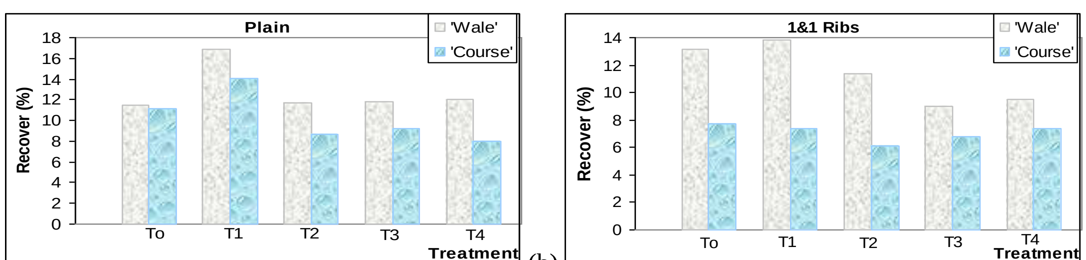
(a)  (b)

Figure 7:- Recovery percentage variation in wale and course directions; for plain (a) and 1&1 Rib (b).

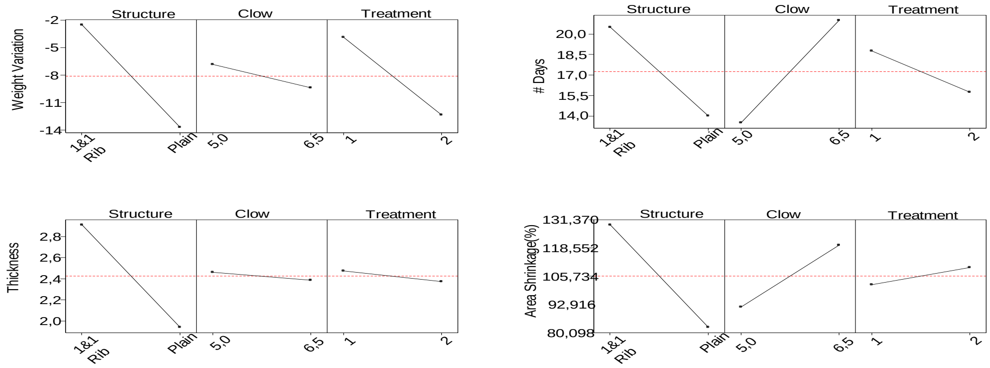
Main effects plot

Main effects plot drawn with Minitab software are used to describe the impact of each factor on the different responses. Minitab plots the means at each level of the factor and connects them with a line. A reference line at the grand mean of the response data is drawn. A main effect occurs when the mean response changes across the levels of a factor. So here we have the means of the response variable for each level of a factor.

Water effect

The impact of the nature of environment (wet or dry) is studied by comparing dry relaxation treatment T1 results and those ones of the cold wet treatment T2 on the above-mentioned responses.

As shown in diagram *D1*, water has presented a negligible effect on area shrinkage and thickness compared to weight variation which is a main factor in knitting trade. Thus, water is determinant on the knitted structure final state.



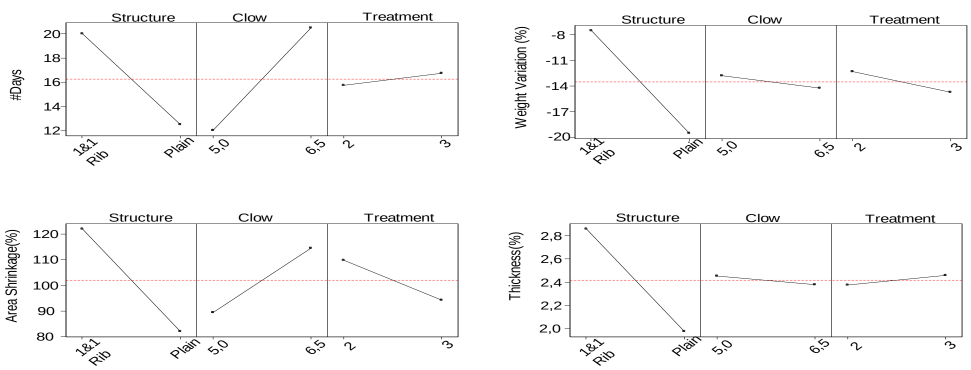
D1 Main effects for Weight Variation, area shrinkage and thickness

Bath temperature effect

To check heat effect on the different responses, main effects plots are drawn comparing treatment T2 to treatment with 40° C bath temperature T3.

The plot reported in diagram *D2* shows that heat parameter remains a remarkable effect on area shrinkage and number of days to reach dimensional stability.

Whereas, for the rest of responses, 40°C bath temperature has no significant effect.

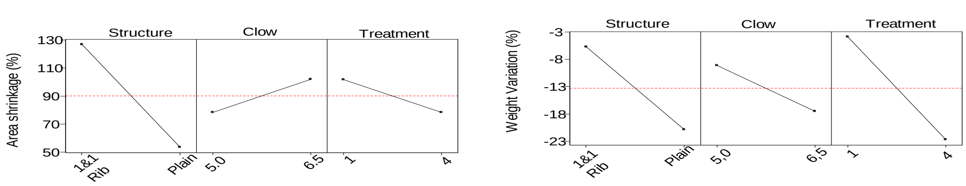


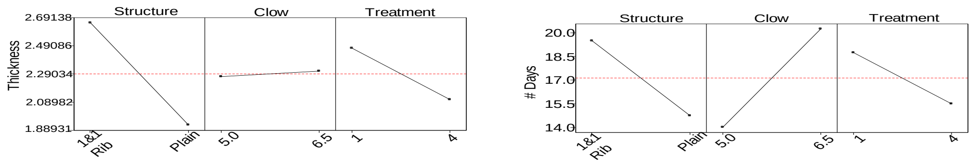
D2 Main effects (data means) for area shrinkage, thickness, weight variation and days for stabilization

Bath temperature and vibration effect

As shown previously, the effect of water and temperature has had principal changes not on the different responses but rather in some ones and for some clows. Whereas, the combination of water vapour, temperature and vibration when relaxing has entirely illustrated the major effect on most responses (*D3*).

By comparing dry and Relaxlab relaxation, we notice an important effect of structure type on area shrinkage, thickness, weight variation and number of days to reach stability. A lower effect is attributed to clow with the exception of the number of days for stabilisation response.





D3 Main effects for area shrinkage, Weight variation, Thickness and # of days

Interaction plots

To assess the presence of interaction between factors namely structure, clow and treatment, we plotted interactions diagrams using Minitab software. An interactions plot is a plot of means for each level of a factor with the level of a second factor held constant. Parallel lines in an interactions plot indicate no interaction. The greater the departure of the lines from the parallel state, the higher is the degree of interaction.

Interpreting The Results

The graph *D4* displays a full interactions plot matrix for all two-factor combinations. Each pair of factors provides two panels as summarized below

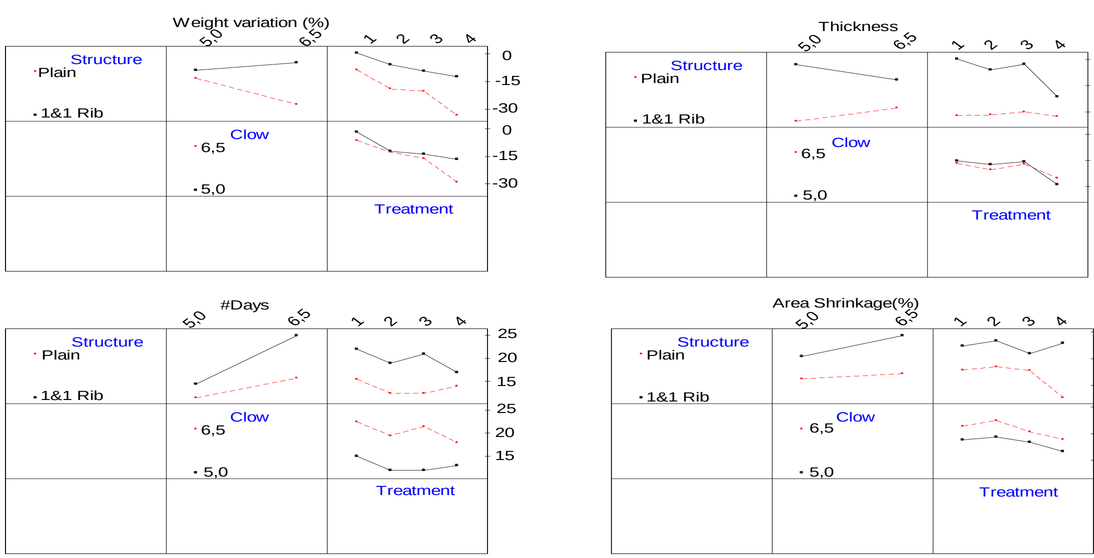
Structure and clow

Both panels indicate that these two factors interact with a negligible interaction for area shrinkage. Plain and 1&1 rib knits have opposite slopes when increasing clow.

Structure and treatment

The interaction here does not remarkably seem as strong as it does for structure and clow.

Clow and treatment: No panel indicates a clear interaction. All lines are approximately parallel, with the possible exception of the weight variation for relaxlab relaxation.



D4 Interaction plots on shrinkage, thickness, weight variation and days for stabilization

Conclusion:-

For both plain and 1&1 Rib samples, increase in fabric clow generates a rise in fabric wale shrinkage for each relaxation treatment. The increase of shrinkage in wale rather than course is essentially explained by the pulling force exerted when knitting.

The results showed a linear variation of structure parameters with the inverse of loop length as well as a wale recovery more apparent than in course.

The three factors contributing to the relaxed state affect the loop shape and the recovery percentage of both plain and 1&1 Rib knitted acrylic fabrics. Water, temperature and vibration had variable effects with clow on dimensional stability.

The relative strength of the effects namely structure, clow and treatment, across factors, studied through main effects plot have shown a dominant effect of structure. Indeed, no significant interaction was revealed between factors.

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